

MediaBin (formerly Iterated Systems, Inc.)

Fractal-Based Technology to Compress Digital Image Files

In the early 1990s, when personal computers (PCs) were becoming increasingly commonplace at home and at work, the demand for more pictures and videos in personal computing applications increased. Computing technology at the time, however, was not able to process, display, or store image files because they were significantly larger than text files. Early modems, which operated at speeds such as 14.4 kilobits per second over analog phone lines, could not transmit large image files. In 1991, Iterated Systems, Inc. (ISI) proposed a research project to the Advanced Technology Program (ATP) to exploit common patterns in image files, reducing them and converting them to their fractal codes. The codes would then be stored in a separate chip, rather than in the computer's memory chip, to allow an easy transition to newer machines as memory, software, and hardware improved. ATP awarded ISI cost-shared funds because of the technology's high technical risk and potential applications for image databases within the real estate, automobile insurance, desktop publishing, medical, defense, and other diverse industries. ISI succeeded in developing compression technology that enabled the fast transmission of relatively high-quality (though not fully high-fidelity) images. However, changes in the market made ISI's innovation obsolete. By the end of the ATP-funded project in 1995, use of the Internet had become widespread, thus reducing the need to store vast image libraries on PCs. ISI decided not to pursue further research into high-fidelity digital image compression using fractal-based codes, and the company never commercialized the technology.

COMPOSITE PERFORMANCE SCORE

(based on a four star rating)

No Stars

Research and data for Status Report 91-01-0057 were collected during October - December 2001.

Technology Unable To Transmit and Store Images

In 1990, image compression (that is, the ability to reduce the size of large, graphics-heavy files for easier storage and transmission) was one of the keystones in the development of future computer imagery. The need to share images and video between PCs and to electronically store them was increasing in those industries that relied on image databases, such as real estate, automobile insurance, desktop publishing, medical, and defense. The demand for image compression, transmission, and storage was increasing, in part because uncompressed digital images and videos required much more memory and internal storage space than PCs could provide. Moreover, memory and storage space requirements were much higher than the complexity of the images

seemed to require. At the time, there was no adequate technology that could compress images into manageable sizes in order to easily store them or transmit them across analog lines.

ISI's Unique Idea Involves Mathematical Approaches

When ISI applied for ATP funding in 1991, they proposed a unique idea for using mathematical approaches to image compression. Although mathematicians worldwide were beginning to use fractals to attempt to compress images, at the time of ISI's ATP application, these mathematical methods represented too high a risk for traditional sources of venture capital. ATP funding, ISI suggested, would accelerate potential advances in fractal-based image

compression by up to two years. ATP considered the technology's immediate benefits as well as its possible widespread application throughout many diverse industries and awarded \$1.57 million to ISI for a three-year research project.

Memory Device Will Compress and Decompress Images

ISI's ATP award would allow the company to conduct research into fractal-based image compression in order to produce high-fidelity images with small file sizes. Specific end results of the proposed project would include building prototypes of a low-cost, real-time decompression chip and a compression system based on the algorithms developed in the basic research phase of the project. ISI envisioned that the decompression chip would not require multiple frame buffers for video decompression, greatly reducing the chip memory required and enabling it to handle both video and still images quickly and easily. ISI proposed to create a memory device that would have the ability to compress and decompress video images. This memory device would keep the images separate from the PC's hard drive; would handle the conversion of large and cumbersome viewable images into small, storable files; and would easily store coded compressions of images and videos.

In addition to the substantial reduction in storage space offered by a fractal-based compression system was the appeal of decompression that was not dependent on a specific degree of resolution. ISI demonstrated with a photograph of a gecko that a poster-size blow-up of the gecko's eye could have the same resolution as the full body shown in the original postcard. This ability to provide any degree of resolution desired by the end user would support manipulation of image size. Since image-viewing software was projected to evolve rapidly throughout the early 1990s, resolution-independent storage would allow the end user to decide how much computer memory would be used in viewing each photo and would allow the image to be viewed by future generations of ever-improving display software. ATP saw ISI's proposed further development of the fractal image-compression technology as a potential springboard to industry-wide improvements in image processing and communication.

Image Compression Could Enable Computerized Image Libraries

Image compression had immediate potential applications in several industries that rely on image databases. For example, there was a daily need to store, catalog, use, and transmit large numbers of images within industries such as real estate, automobile insurance, desktop publishing, medical, and defense. In order to use PCs to speed these processes, images needed to be stored and transmitted over a standard analog line. Without improved compression and storage software, a relatively small image library of a dozen images or even one video would completely fill the PC's hard drive and would take hours to transmit over analog lines; thus, these excessive storage requirements precluded the widespread use of computerized image libraries.

Technical Challenges Posed by Fractal Codes

The Fractal Transform method for image compression, created by ISI in 1990 (prior to the ATP-funded project), held promise for achieving very large compression ratios for still and video images, while maintaining high fidelity to the original, especially in the case of high-resolution images. The higher the compression ratio, the less space the compressed image requires within operating memory and computer storage. The problem in the past, however, was that the image degraded at higher compression ratios, making high-fidelity images impossible to compress and maintain.

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The Fractal Transform method exploited redundancies in two- and three-dimensional images to generate a representation in terms of readily decompressed fractal codes. ISI's initial success in using common image patterns to compress images accurately convinced the company's software engineers that they could develop a solution to the image compression and storage problems that would be welcome in the PC marketplace.

ISI's three technical challenges, however, were daunting. The first challenge was to develop fractal codes that could accurately compress and decompress all image-based still and video media that could possibly be used within a computer. Because PCs enabled the use of both still images and videos as part of daily operations, any compression software would need to handle both media with nearly perfect accuracy. The second challenge was to create a chip that could sit as a separate entity from the PC's hard drive and could compress and decompress large-scale images and videos using fractal codes. This would enable the compression and decompression to operate as a stand-alone image/video storage device that could remain within the PC even as hard drives were updated and as software evolved. The third challenge was to create a hardware-based, real-time compression system for high-resolution video images. This compression system would allow the immediate creation of video databases directly from the recording media that could then be accessed and manipulated by the memory-decompressor chip.

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In 1991, ISI believed that its Fractal Transform method could possibly meet these technical challenges. However, the technology at that time was not advanced enough to be used as anything but baseline technology from which to research fractal-based compression. The technology still required innovative algorithms developed by mathematicians, engineers, and computer professionals that could compress and decompress images and code them in a fashion that was compatible with the PC industry.

ISI Pursues Multiple Research Approaches

ISI pursued multiple paths in its research. For still image research, the company undertook two approaches: a conservative approach, which built on the existing idea of fractal-based compression; and a more speculative approach, which combined the best of fractal technology with the best of other technologies.

The conservative approach did not produce results that were cost competitive with technology already in the market; therefore, ISI concentrated on the more speculative approach. After 15 months, ISI was able to produce prototypes of compressors and decompressors that proved superior to other available technologies. However, the company was not able to maintain high fidelity to the original images because nonfractal conversions were also used. Therefore, ISI decided not to pursue development along this path.

The company also pursued two approaches to its research into video compression. As with still-image compression, purely fractal-based compression costs too much to produce. The approach that combined motion tracking with fractal-based compression offered the most promise. It used a new class of image maps, which enabled previously created detail to be moved instead of reconstructing new detail. ISI's efforts were directed at increasing compression speeds. Ultimately, speeds on the order of 25 seconds per frame were achieved on Pentium 90-equipped PCs for single color frames with a resolution of 320x240 dots per inch. At the time, these results were excellent, as well as highly encouraging.

Finally, the major goal of ISI's ATP-funded project was to produce a prototype, low-cost decompressor chip, implementing the algorithm produced by these research efforts. Researchers envisioned a chip that could store fractal codes and could produce images from them without requiring a significant amount of memory. ISI evaluated three alternatives during the development of this chip: the first alternative was for low-resolution images, the second was for high resolution, and the third was for enhanced resolution.

ISI did reach new heights in compression time and image clarity, and this technology is still in use in some image libraries.

Testing revealed that the best route to pursue was the development of a high-resolution chip. ISI completed and tested the core design, but by the time its ATP-funded research ended in 1995, use of the Internet had become widespread and market demand for image compression had shifted to small pictures for web

pages at low bit rates for mass Internet application. Since the ATP-funded research was geared towards high-bit-rate transmission of large images in high fidelity, the market shift was so great that the ATP-funded research no longer applied.

ISI Attracts Additional Funding

Even though the market shifted and made ISI's research somewhat inapplicable, the project helped ISI to attract additional funding. First, the company gave a presentation at a 1995 fractal image encoding conference at the North Atlantic Treaty Organization (NATO) Advanced Study Institute in Norway and gained enough credibility through its early-stage image compression technology that it was able to initiate a public offering listed on the speculative Norwegian stock exchange. Second, ISI secured a \$36 million contract with MCI to work on image compression. ISI disclosed its research from the ATP-funded project to MCI as part of the due diligence process before the contract was approved, providing MCI with 25 internal technology research reports.

Conclusion

ISI received an ATP award to pursue a research plan that would attempt to use fractal codes to compress, store, and transmit image files. Ultimately, fractal codes could not be used without incorporating some nonfractal-based coding. This caused image deterioration and prevented true high-fidelity image storage. Even without full high fidelity, ISI did reach new heights in compression time and image clarity, and this technology is still in use in some image libraries. The emergence of the Internet and broadband connections, however, reduced much of the mass-market potential for computerized image libraries.

PROJECT HIGHLIGHTS

MediaBin (formerly Iterated Systems, Inc.)

Project Title: New Technology To Compress Digital Image Files (High-Fidelity Digital Image Compression)

Project: To develop a prototype digital image storage and decompression chip using fractal transform image compression technology.

Duration: 7/1/1992-6/30/1995

ATP Number: 91-01-0057

Funding (in thousands):

ATP Final Cost	\$ 1,568	73%
Participant Final Cost	<u>586</u>	27%
Total	\$ 2,154	

Accomplishments: With ATP funding, ISI accomplished the following:

- o Produced prototypes of compressors and decompressors using a combination of fractal and nonfractal elements, which proved to be superior when benchmarked against other available technologies.
- o Created more than 25 internal technology research reports that summarized the results of experiments conducted during the research and development process.
- o Secured a \$36 million contract with MCI, closed other large deals, and attracted business talent for the company based on increased credibility that resulted from this project.
- o Disseminated project knowledge in July 1995 at a fractal image encoding conference at the NATO Advanced Study Institute in Norway. The transcript of that talk is publicly available worldwide.

Commercialization Status: Prior to the ATP project, ISI did not have any commercial products on the market that were based on fractal-compression techniques. During the project, ISI developed fractal techniques for image compression and decompression. However, the company later changed its business goals and discontinued further development of the technology.

Outlook: Fractal technologies have had some commercial use. In 1992, Microsoft used its own fractal-compression techniques to enable the release of its CD-ROM-based encyclopedia, Encarta. Several other vendors that offer fractal compression market their products for dynamic resizing of images for applications such as billboard manufacturing and company web sites. Experts in the field, however, predict that techniques based on wavelets and object-based technologies will continue to maintain their strong lead in compression technology research, making it harder, but not impossible, for fractal techniques to compete.

Composite Performance Score: No Stars

Number of Employees: 39 employees at project start, 55 as of December 2001

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